of the Indian Ocean belongs to one system as such an extended nodal line would imply.

We are therefore led to believe that there is a region of small semidiurnal tides extending from Freemantle to Mauritius Island, and that the absence of a good tide is due to the fact that the distance between western Australia and Madagascar does not approximate to λ or to $\frac{1}{2}\lambda$ as an east-and-west stationary wave would require. However, on account of the progressive waves in various parts of the North Indian Ocean, there may be a small wave progression northward across the region of small tides just referred to.

There is some inward progression from Rodriguez northwesterly toward the Farquhar Islands and Cape Amber, but it is to some extent mixed up with the stationary wave around northern Madagascar. That is, it is a somewhat irregular progression. In fact the tide between Rodriguez Island and Cape Amber is due chiefly to the rise and fall at the north end of Mozambique Channel. That is, a species of dependent oscillation, part stationary and part progressive, is maintained by this rise and fall. A somewhat similar effect may exist off Northwest Cape, Australia.

MISCELLANEOUS REMARKS.

Upon referring to fig. 1 it will be noticed that because of proximity to nodal lines the range of tide around Ceylon and southern Hindustan must be small. For the same reason the tide along the outer or southwestern coast of Sumatra should be small. The tide at the western end of the southern coast of Java should be smaller than is the tide farther east. All these requirements accord well with the observed facts as can be seen upon referring to the large map, fig. 5.

The distribution of the cotidal lines through each of the nodal lines respectively located east of Ceylon, off the Malabar coast and off Somaliland, has not been made, upon the map, in accordance with any assumed mathematical law. The lines are chiefly conjectural although in accord with the observations.

Upon measuring the dimensions of the oscillating areas, it may appear that the actual lengths are a trifle too short for the existence of large tides, although no definite criterion has been laid down in such matters. There are difficulties in the application of Lagrange's rule to even a canal-like body of variable depth. It seems, however, upon comparing the times required for the eruption of Krakatoa to have been felt at ports in India, Arabia, and Africa, that the areas as laid down on fig. 1 must have a free period sufficiently long to permit good stationary oscillations.[12]

The map shows several cases in which a derived wave is produced at a sudden shoaling.[13] For example, the Gulf of Martaban, the vicinity of the mouths of the Ganges, the Gulf of Cambay, and off the Gulf of Kutch. The progression north of Australia is due largely to such sudden shoalings as the Sahul Bank. A dependent stationary wave is apparent in the Gulf of Kutch, and some traces of dependent stationary waves, shown in the acceleration of the times of the tide, can be seen at the 80-mile beach (on the northwestern coast of Australia) and near and in the mouth of the Hugli River.

Sokotra Island and neighboring shoal have some influence upon the distribution of the cotidal lines in that locality. A similar remark may be made concerning the Laccadive and Maldive islands.

In passing through Sunda Strait, the range rapidly diminishes, while the cotidal lines bunch up.[14] A somewhat similar statement is true of the narrow straits farther east.

The tide wave entering Palk Strait proceeds southwesterly up Palk Bay, at about the rate due to depth, nearly to Adams Bridge.

The tide proceeds southeasterly through Malacca Strait, but not at the rate due to depth alone, excepting in the broader portion.

EVIDENCE OBTAINED FROM TIDAL STREAMS.

The directions of the observed tidal streams as given in the Admiralty Pilots afford some clue to the character of the tidal oscillation, especially in localities where the motion is rectilinear. Around the Maldive Islands the flood stream sets easterly and around the Chagos Archipelago it sets southeasterly. In the northern end of Mozambique Channel the flood sets southerly and in the southern end northerly. Moreover, we find that flood slack occurs soon after high water in the channel, as a stationary oscillation requires. These facts could have been inferred from figs. 1 and 5.

On the southern coast of Cape Colony, from Table Bay eastward to Port Alfred, no sensible tidal stream exists although there is a moderately large rise and fall. This is in accordance with the lines of motion terminating at the shore which runs nearly perpendicular to them. See fig 1.

The southern shore of Baluchistan lies at the loop of the half-wave area as also of the whole-wave area. Consequently the tidal streams should there be weak, and observation shows this to be the case.

Across the shoals and around the islands east and northeast of Madagascar, there are strong tidal streams. According to the map of cotidal lines, this is a region where the tide varies both in time and in range; such conditions always imply large accelerating forces for the water masses and generally large velocities, especially over shoals.

In the short straits which separate from one another the islands east of Java, the currents should be swift. This statement is confirmed by observation. But whether or not the time of maximum flood velocity is an hour or so before the time of high water at the southern ends of the straits has not yet been ascertained.

Strong tidal currents occur among the Nicobar Islands and generally among the Andaman Islands. At Table Island the streams turn at about the times of high and low water.

The streams in the Gulf of Suez accord well with the notion of a stationary wave, the times of slack water very nearly coinciding with the times of the tide at the head of the gulf.

THE ENDOWMENT OF RESEARCH IN METEOROLOGY.

[In the summer of 1902, the Chief of the Weather Bureau and other officials had occasion to present to the Carnegie Institution their views on the subject of the application of a portion of the funds of that institution to the promotion of research in meteorology. The ideas then presented were not very different from those lately defended in an interesting paper of a general character by Professor Chamberlin, the eminent geologist of the University of Chicago, who has himself published important papers bearing on the connection between the atmosphere and geology. In the belief that Professor Chamberlin's paper must contribute to promote research in meteorology and elevate the standing of our science in the colleges and universities of the country, we have requested him to present it for publication in the MONTHLY WEATHER REVIEW; in an early number we shall also submit the special reports presented to the Carnegie Institution.—ED.]

HOW CAN ENDOWMENTS MOST EFFECTIVELY AID RESEARCH?

By Prof. T. C. CHAMBERLIN, Head of the Department of Geology, University of Chicago.

I am not sure that I have rightly apprehended the special phase which it is desired the discussion should take, if, indeed, it is desired that it should take any one trend rather than another among those that are perhaps equally embraced under the broad theme announced. I have interpreted the above question as though it read, *By what assignment of endowments can research be most effectually aided?*

I assume that, with some rare exceptions, endowments may

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[12] Cf. The Eruption of Krakatoa and Subsequent Phenomena, tabulation opposite page 148 and Plate XXXV.

[13] Cf. Appendix No. 7, United States Coast and Geodetic Survey Report, 1900, lemma 10, § 70.

[14] Ibid, §§ 104–106.

be welcomed in whatever form they may come, but that their effectiveness may be much greater or much less according as they are judiciously or injudiciously placed. Some endowments indeed may be so hampered by restrictions that they are better declined than accepted, but these, it may be hoped, will grow more and more rare as intelligence relative to what is wise in the endowment of research increases.

I assume that the principles which control modern success in most other enterprises will be found applicable in general to the endowment of research, and that among these principles are specialization in subject, careful choice of talent, the largest possible use of the highest talent, the greatest possible avoidance of inferior talent, concentration of effort by institutions of limited means, and coordination of effort between institutions of whatever means, rising to close combination in effort whenever practicable. I assume that the discussion should take the form of concrete suggestions rather than of general principles.

1. *Endowment of chairs of research.*—The time is fully ripe for the special endowment of chairs of research. The promise of results from such endowment is very great. Not a few of the chairs in our leading universities are devoted chiefly to research, but this is usually due more to the personal force and peculiar endowments of the occupant than to self-determined provision on the part of the institution or its patrons. The chairs that are endowed primarily for research are very rare. There ought no longer to be a struggle on the part of the capable investigator to free himself from obligations to teach so that he may devote himself to creative work. It need not be urged here that creative work is more serviceable to mankind than expositional work or even disciplinary training. Real capability for investigation of a high order being granted, all pressure from the institutional environment should be such as to impel the investigator to give himself as undividedly as possible to research.

The endowment of chairs of research is here first urged not because it is superior to the modes of endowment yet to be considered, but because it requires but a moderate gift, as gifts now run, and is therefore within the reach of a large number of possible patrons, to whom endowments in more than six figures are impossible. From $100,000 to $200,000 will effectively endow a chair of research from which great results in time may be expected. Endowments of less amounts may be made to provide that a specific fraction of the time of the occupant of a chair shall be devoted to investigation, and thus creative work may be effectively promoted by a modest sum.

2. *Endowments for departmental research.*—No scientific staff of a university should regard itself as fulfilling its mission in any adequate way if it does not devote an appreciable portion of its energies to investigation. At present the provision for research is usually rather vague and uncertain, if indeed there is specific provision for it at all. While theoretically recognized as a proper function and perhaps cordially appreciated by the authorities of the institution, there is in actual practise a constant struggle between the demands of instruction and the desire for investigation, in which the preponderance of pressure growing out of the rapid growth of most universities too often lies on the instructional side. Relief for research is to be found in endowments specifically devoted to the purpose. It is here proposed that the endowment shall be made to the *department* rather than to a *specific chair*. The application of the revenue is, in this case, broader and more plastic than in the endowment of a specific chair. The function of research may be distributed among the members of the staff according to their capabilities and tastes, and thus give to them something of the touch and inspiration of creative work, while they still retain an instructional function of greater or less degree; or it may be concentrated at one time in a given line by a given member, and at another time in a different line by another member as conditions may favor. It is not in all cases, perhaps not in most cases, altogether best for the investigator to be relieved entirely from instructional function, since the exposition of his work has its good effect in forcing the organization of his thought. The critical review of it, as he assumes the obligation of presenting it to younger minds, is wholesome, as are also the questions and discussions incidental to such presentation. But the amount of such profitable instructional work has rather severe limitations. Endowments for departmental research may wisely range through the permutations of six figures into those of seven.

3. *Endowments for special research combinations.*—The early settlers of the broad fields of this country were accustomed to leave a wide, unbroken "turn-row" along their line fences, and long after the general settlement of the country these presented almost the only remaining virgin soil. It has been much the same in the pioneer cultivation of the scientific fields. Between the recognized realms of physics, chemistry, astronomy, biology, geology, and other sciences there is a border ground, which has been less cultivated than these recognized fields, and here lie the richest virgin grounds of the scientific domain. Their adequate culture requires the cooperation of men trained in the several cognate fields. A combination of men skilled in physics, astronomy, and mathematics is essential to the highest results in astrophysics. An association of men skilled in chemistry, physics, mathematics, and geology is requisite to the most promising attack upon the complicated problems of geophysics; and so of other broader grounds. There is, therefore, an eminent opportunity to promote research by endowments which shall provide for the cooperative investigation of two, three, or more men whose combined talents and training may fit them to engage jointly in a common inquiry. The endowment here must be large to be effective, but where it can be made adequate its promise of fruitage is most eminent.

4. *Endowments for schools or colleges of research.*—This is but a larger phase of endowments for departmental research, but with this difference; in the latter it is presumed that the departmental staffs of universities will continue to be, as at present, organized primarily for instructional work, while in the proposed endowment of schools or colleges of research it is presumed that research will be the dominant feature and instructional work will be incidental. Very great creative results would flow from the judicious establishment of schools of research in chemistry, physics, biology, geology, and other sciences analogous to the staffs of astronomical observatories where investigative work is now the declared purpose.

In the initial stages of the development of this scheme it is assumed that these schools of research must be individual and localized in different institutions, since no institution does now, or probably can in the immediate future, command the means for the establishment of such schools in all the departments that invite investigation. But if one institution were to concentrate upon one science or one limited group of sciences and another institution upon another science or limited group of sciences, the universities of the country might *together* cover the field effectively. It were much better, to my mind, if the aspirations of a university should take a definite specialized form of this kind in some one or some few lines, than that it should distribute its efforts over all lines with inferior success in each because of its limitation in men and means. It is probably not beyond the resources of any great university to secure the development of some one or two effective schools of research if it were content to make a selective effort and were wise enough to do this.

5. *The evolution of universities into assemblages of research schools.*—Ultimately it is to be hoped that each of the greater universities will succeed in developing a large group of research schools, and that with this there will come a gradual

reorganization of the constitution of universities, involving their transition from the function of personal education to the higher function of creative work. The English universities are now essentially an aggregate of colleges, each of which is mainly devoted to personal education. The ideal of a university, as here entertained, would make the coming university an association of colleges of research for the benefit of mankind as a whole. In the English university the several colleges cover essentially the same ground and are duplicative in their work and competitive in their relations. In the ideal university the colleges would occupy distinctive fields and be supplementary and stimulative toward each other and in no sense duplicative. Their primary function would be creative work for all mankind rather than didactic or disciplinary work for individuals.

6. *Endowments for independent institutions of research.*—The preceding discussion has related essentially to universities. Aside from organizations under governmental patronage, universities are at present the chief agencies of research. It is doubtless quite within the truth to place to their credit by far the largest amount of creative work done independently of government patronage. None the less, there is, to my view, a large and special place for independent institutions of research and endowments for such independent institutions are invited by their promise of fruitfulness. Every university has its special relations with some portion of the social organism by which it is fostered and to which, because of that fostering, it is in special bonds. While this relationship of support and consequent bondage is one of greatly preponderating good, it is not without its moiety of trammeling and limitation. In order to fill out the full complement of institutions suited to the most effective promotion of creative work, another class of institutions not subject to these relations is needed. These needed institutions might indeed likewise have their own special relationships with their own limitations and trammelings, but they should none the less fill a place not occupied by existing universities, nor likely to be occupied by them. More than this, these independent institutions of research should stand in relations of wholesome competition to the universities and by representing a different phase of endeavor should thereby contribute to the broadening of the sum total of influences at work for the promotion of research.

7. *Endowments for the higher coordination of research.*—Whatever may be the development in any of the institutions to which the phenomenal generosity of American men of means have contributed, or may yet contribute, it must still remain true that for an indefinite time the whole field of research can not be effectively cultivated by any institution, and there must be a large need for adjustment and cooperation, that the energies of research may be distributed to the greatest advantage. Even if it were possible for any institution to reasonably attempt the whole field, cooperation and coordination in research need to be cultivated to prevent wastage by unnecessary duplication and to give the greatest and best results by the adjustment of work to work. At the present stage of development provision for cooperation is eminently desirable and endowments devoted to this end give promise of being preeminently productive. The ideal scheme of coordination contemplates the correlation of talent and equipment in all the institutions devoted to research without regard to institutional relations. It should be as free as human nature permits from predilection toward one of institutional organization rather than another. It should be its function to develop, to use, and to coordinate talent, effort, and equipment wherever it may be, quite regardless of institutional connection, or locality, or of other matters than its possibilities of fruitfulness in creative work.

It need not be remarked here that we seem to be on the threshold of this great realization, and it is not too much to hope that each of the other forms of endowment will, in some large measure, appeal to the generosity and appreciation of American men of wealth.

HAWAIIAN CLIMATOLOGICAL DATA.

By CURTIS J. LYONS, Territorial Meteorologist.

OBSERVATIONS AT HONOLULU.

The station is at 21° 18′ N., 157° 50′ W. It is the Hawaiian Weather Bureau station Punahou. (See fig. 2, No. 1, in the MONTHLY WEATHER REVIEW for July, 1902, page 365.) Hawaiian standard time is 10h 30m slow of Greenwich time. Honolulu local mean time is 10h 31m slow of Greenwich.

The pressure is corrected for temperature and reduced to sea level, and the gravity correction, —0.06, has been applied.

The average direction and force of the wind and the average cloudiness for the whole day are given unless they have varied more than usual, in which case the extremes are given. The scale of wind force is 0 to 12, or Beaufort scale. Two directions of wind, or values of wind force, or amounts of cloudiness, connected by a dash, indicate change from one to the other.

The rainfall for twenty-four hours is measured at 9 a. m. local, or 7.31 p. m., Greenwich time, on the respective dates.

The rain gage, 8 inches in diameter, is 1 foot above ground. Thermometer, 9 feet above ground. Ground is 43 feet and the barometer 50 feet above sea level.

Meteorological Observations at Honolulu, March, 1903.

Date.	Pressure at sea level.	Temperature.		During twenty-four hours preceding 1 p. m. Greenwich time, or 1:30 a. m. Honolulu time.									Total rainfall at 9 a. m., local time.
				Temperature.		Means.		Wind.		Average cloudiness.	Sea-level pressures.		
		Dry bulb.	Wet bulb.	Maximum.	Minimum.	Dew-point.	Relative humidity.	Prevailing direction.	Force.		Maximum.	Minimum.	
	*	†	†			‡	‡		§				
1	30.01	66	60	73	59	52.7	63	nne.	2	4–1	30.09	29.99	0.00
2	29.99	65	60	74	61	56.5	67	ne.	2	2	30.06	29.95	0.00
3	30.00	60	59.3	73	64	58.5	73	ne.	3	5–1	30.05	29.94	0.04
4	29.99	60	59	75	59	59.3	80	ne.	2–0	5–2	30.04	29.94	0.01
5	29.99	59	57.5	76	58	59.0	76	e–se.	1–0	5–2	30.03	29.93	0.00
6	29.99	64	62.5	78	57	59.3	76	se–ne.	1–0	3–0	30.04	29.94	0.00
7	30.00	60	58	78	64	62.5	80	s–n.	1–0	3–0	30.05	29.95	0.00
8	29.98	64	61.5	78	60	59.7	79	sw–n.	1–0	1–0	30.05	29.95	0.00
9	30.01	69	63.5	78	60	61.7	77	sw.	0	1–3	30.04	29.94	0.00
10	30.08	65	57.3	76	65	60.3	72	sw–ne.	1–3	5–2	30.09	30.00	0.00
11	30.08	65	56	73	64	52.7	60	nne.	3–4	2	30.12	30.04	0.00
12	30.02	67	59.5	73	65	52.3	59	ne.	4–3	2–0	30.12	30.01	0.00
13	29.95	64	61.5	76	65	57.5	65	ne.	3	5–1	30.03	29.94	0.00
14	29.89	68	66.3	76	62	62.3	78	sw.	1–0	6–10	29.99	29.88	0.01
15	29.79	67	66.3	78	68	66.3	86	sw.	1–0	10	29.92	29.80	0.54
16	29.82	63	62	76	66	64.0	86	sw–n.	1–0	10–4	29.87	29.77	0.01
17	29.86	58	56.5	70	62	58.5	81	nw–ne.	1–0	10–8	29.93	29.85	0.00
18	29.94	59	55.5	72	57	53.7	67	nw–n.	1–3	10–1	29.95	29.87	0.02
19	29.99	64	55	73	56	53.3	67	nne.	3	3	30.02	29.92	0.00
20	29.99	61	54.5	72	63	50.0	58	nne.	3–1	5	30.04	29.95	0.00
21	29.93	57	55.7	72	58	51.5	65	nne.	3	3	30.02	29.95	0.00
22	29.82	58	57	72	56	56.3	82	sw–n.	1–0	0–8	29.95	29.81	0.00
23	29.81	65	62.5	73	57	58.5	76	sw–w.	0	10	29.88	29.78	0.00
24	29.88	62	61	74	65	61.3	80	w–sw.	0	10–5	29.89	29.81	0.00
25	29.89	58	56.5	77	61	59.3	73	w–n.	3–0	0–10	29.95	29.86	0.00
26	29.86	59	57	76	58	55.5	72	sw–w.	2–0	0–8	29.94	29.82	0.00
27	29.90	63	57.5	75	58	55.3	70	nw–w.	2	0–5	29.94	29.85	0.00
28	30.00	66	59	75	57	55.5	70	ne.	3–4	7–1	30.04	29.90	0.01
29	30.09	66	60	73	64	53.7	61	ne.	4	3–0	30.13	30.00	0.00
30	30.10	65	57.5	73	65	57.5	70	ne.	5–3	3	30.13	30.06	0.17
31	30.10	66	59.5	72	62	53.0	62	ne.	4–2	4	30.15	30.08	0.22
Sums	......	......	......	......	......	......	......	....	......	......	......	......	1.03
Means	29.690	63.0	59.2	74.5	61.3	57.5	72.3	....	1.8	4.2	30.017	29.916	......
Departure	—.047	......	......	......	......	—4.0	+0.3	....	......	—0.4	......	......	—2.73

Mean temperature for March, 1903, (6 + 2 + 9) ÷ 3 = 67.3; normal is 70.9. Mean pressure for March, 1903, (9 + 3) ÷ 2 = 29.970; normal is 30.017.

* This pressure is as recorded at 1 p. m., Greenwich time. † These temperatures are observed at 6 a. m., local, or 4.31 p. m., Greenwich time. ‡ These values are the means of (6 + 9 + 2 + 9) ÷ 4. § Beaufort scale.

Maximum thermometer set at 9 p. m. and minimum at 2 p. m., local time.

Mean temperature table.

Stations.	Elevation.	Mean max.	Mean min.	Cor. av'ge.
	Feet.	°	°	°
Pepeekeo	100	73.1	64.8	68.2
Waimea	2,730	70.5	54.2	61.6
Kohala	521	74.3	62.6	67.7
Nahiku	1,600	......	......	......
Waiakoa	2,700	71.3	51.7	60.8
Ewa Mill	50	......	......	......
United States Magnetic Station	50	78.2	59.0	67.9
United States Experimental Station	350	75.8	63.0	68.7
W. R. Castle	60	78.0	55.0	67.2
Tantalus	1,725	......	......	......
Hilo	40	77.2	64.0	69.9
Waikiki	15	75.2	62.6	68.2